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THE AMERICAN

METEOROLOGICAL JOURNAL.

VOL. III. ANN ARBOR, JUNE, 1886. No. 2.

CURRENT NOTES.

RAINFALL CHART OF CALIFORNIA.—Lieut. Glassford has compiled an instructive rainfall chart for California for the season to February 1, published as a supplement to the *Commercial News and Shipping List*. The chart shows the percentage of precipitation as compared with former years. There are three limited centers of excess: In the Sacramento Valley, near Fremont, where the percentage reached 150; on the upper San Joaquin, where it reaches 200; and near the coast in Santa Barbara and San Luis Obispo counties, where it reaches 125.

THE WARNER PRIZE ESSAYS.—The prize essays which were to treat of the recent sun-glows and related phenomena have been examined and, as I learn from Dr. Swift, director of the Warner observatory, with the following result: Dr. Kiessling, of Hamburg, obtains the first prize of two hundred dollars; James E. Clark, Esq., of York, England, gets the second prize of one hundred and fifty dollars; the third is divided between the Rev. S. Bishop, of Honolulu, and H. C. Main, of Rochester, New York. Professor Abbe, of Washington, Dr. Charles Braun, of Mariaschein, Bohemia, and Professors Upton, of Providence, H. A. Hazen, of Washington, and W. M. Davis, of Cambridge, receive each a medal of honor. Dr. Warner was very fortunate in calling out so much valuable matter. Mr. Bishop's paper has already been printed. The others have not yet reached me.

SHORT PERIOD OSCILLATIONS IN LAKES. SEICHES.—Professor Forel, of Morges, Switzerland, has in recent years devoted much attention to the long known oscillations in the waters of the Swiss lakes, especially in Lake Geneva, and has shown them to be wave-like motions, in which the whole mass of the lake water is set swinging, and consequently the velocity of the wave and thus the period of the *seiche* is a function of the depth of the lake: their origin seems to be chiefly in connection with sudden changes of atmospheric pressure.

The lakes of our country have not been carefully examined in this respect, so far as I have learned; but probably many observers on their shores can testify to their oscillations. A brief contribution to the question is made in the following abstracts from a letter from Chas. Rhodes, Esq., of Oswego, New York, dated April 16, 1886.

Although Mr. Rhodes has kept no record of the rise and fall of our lakes in short periods, he has many times observed such oscillations. For example, near the head of the still water in Oswego river, there is a shallow pool connected with the river by a passage one to three inches deep and ten or fifteen feet wide. The water has frequently been seen to run into this pool for fifteen or twenty minutes, and then change and run out for as long a time; the period was irregular and the fluctuation was estimated to be one to four inches. At other times he has seen a sudden flow of waters, rushing in from the lake (up the river) rising ten to eighteen inches, and followed after half an hour or so by an equally sudden outflow and fall, going as much below the ordinary level as the rise was above it; this would be succeeded by smaller rises and falls till only the ordinary fluctuations occurred. All such large and sudden oscillations were followed by storms of wind, rain, or both.

Additional information is much desired on this subject.

W. M. D.

THE RELATION OF METEOROLOGY TO DISEASE.—This is the title of a paper by F. R. Campbell, A. M., M. D., lecturer on hygiene, Niagara University, presenting many points of interest.

Although his argument treats of localities in general, he especially considers the subject with reference to Buffalo and its vicinity. The average of four years shows the annual temperature at that point to be 46¼ degrees (Fahr.). The highest temperature was 91°, the lowest 14° below zero. From the fact that at some of the lake-port stations in Michigan there is more ozone than in the interior, the writer assumes that there is more than the average of ozone at Buffalo.

Studying the death-rate in Buffalo with his table of meteorological means, Dr. Campbell deduces the following: "1. That the death rate in Buffalo increases directly with the mean annual temperature. 2. That for each degree that the mean annual temperature rises above 45°, the infant mortality increases one per 1,000. 3. That the death rate for persons over sixty years of age diminishes as the mean annual relative humidity increases."

During a season of drought in 1881, in August and September less than a quarter of an inch of rain fell in Buffalo, and the death rate reached 49 per 1,000, all zymotic diseases assuming a more than usually virulent type, dysentery being the cause of the greatest mortality. It is also probable that at the same time there was more than the usual mortality from typhoid fever, as the most recent observations show that deaths from that disease are most frequent when the ground water is low.

In reference to ozone, Dr. Campbell says: "When the amount of atmospheric ozone is greatest, we have the maximum of acute respiratory diseases and the minimum of intestinal diseases; when the amount of atmospheric ozone is least, we have the maximum amount of intestinal diseases and the minimum of acute respiratory diseases. N.

ROYAL METEOROLOGICAL SOCIETY.—The usual monthly meeting of this society was held on Wednesday evening, the 21st of April, at the Institution of Civil Engineers, 25 Great George street, Westminster, Mr. W. Ellis, F. R. A. S., President, in the chair.

Mr. L. J. Petre and Mr. G. B. Wetherall were balloted for and duly elected fellows of the society.

The following papers were read:

(1) "The Climate of Killarney," by the Ven. Archdeacon Wynne, M. A., F. R. Met. Soc. The climate is determined partly by its geographical position, and it has the benefit of proximity to the south-west coast with all the modifying influence of the Gulf Stream. The temperature, however, is locally modified and a decided difference is found to exist between that of Valencia and of Killarney. The author shows that Killarney is colder than many other places in Ireland, and this he attributes to the fact that it is in a great irregular basin surrounded by mountain ranges for about a third, and by hilly plains elevated some hundreds of feet above the lakes on most of the remaining two-thirds of the circle.

(2) "Note on the Probability of Weather Sequence," by Lieut.-Col. C. K. Brooke, F. R. Met. Soc.

(3) "Account of the Cyclone of June 2, 1885, in the Arabian Sea," by Capt. M. T. Moss. The author who was in command of the "S. S. Inchulva," while on a passage to Bombay, had, when near Aden, the misfortune to encounter a most furious storm on the above date. This storm, which was apparently not of very large dimensions, was exceedingly severe and was accompanied by an immense wave which caused several fine steamers to founder.

(4) "Results of Solar Radiation Observations in the Neighborhood of Birmingham, 1875–1884," by Rupert T. Smith, F. R. Met. Soc.

(5) "Results of Meteorological Observations made in the Malay Native State of Selangor during 1884," by A. W. Sinclair, L. R. C. P. These observations were taken at four stations, viz.: Kwala Lumpor, Klang, Kajang, and Kwala Langat. The mean temperature of the district is about 80°, and the rainfall about 90 inches.

COLONIAL CLIMATOLOGICAL STATISTICS.—Notwithstanding that many of the colonies, especially in the tropics, have been occu-

pied for scores of years or even centuries, the climatological information about them is generally very incomplete. In most cases it is not easy to decide such questions as these: Can Europeans reside there in safety? What physicial and intellectual labor can be be performed there? Could prosperous colonies be founded there with entire certainty? What are the especial dangers to be avoided? The means of answering these and similar questions are of the utmost importance, especially to statesmen in these days of revived and active colonial enterprise, but these means are generally lacking. In view of this state of the case, Dr. Charles Zehden, of the Academy of Commerce of Vienna, makes the wise suggestion that climatological data from the various colonies should be systematically collected and published in some single and generally accessible medium. He proposes for this purpose the *Revue coloniale internationale*, published at Amsterdam, and this journal assents to the proposal. It is an excellent suggestion, and no better organ of publication could be found.

Relations of the Atmosphere to Organic Life.—The following summary is compiled from Professor Goodale's recent book on Physiological Botany, and is of interest in contrasting the relations of plants and animals to the atmosphere:

All animals and plants gain the energy needed for the work that they perform by the oxidation of some part of their organic substance. The reception of the oxygen, the oxidation of the oxidizable matter, and the release of the products of oxidation (carbonic acid and water) are collectively termed *respiration;* and this process is much alike in quality in animals and plants, although performed by very different organs, and differing greatly in quantity. A much greater quantity of oxygen is consumed by animals, because they do so much more work than plants. As a rule respiration is a continuous process through day and night in both plants and animals. The amount of carbonic acid given off by one hundred average house-plants is probably exceeded by that evolved in the same time by the burning of a common candle. Respiration is effected by all the

active cells of a plant, and, as above stated, may go on at night as well as by day.

There is another process that is very unlike in plants and animals; this is the preparation of the oxidizable matter to be consumed in respiration. Animals depend chiefly on organic matter for their food; it is eaten, digested, and the needful parts are assimilated to be circulated through the body, and supply the demands of nutrition and growth, to be consumed by oxidation in the lungs or other parts of the body adapted to this end in the process of respiration: assimilation here has a limited meaning. Plants, on the other hand, prepare their food essentially from two inorganic substances: water, derived from the ground through the roots (not from the leaves), and carbonic acid, absorbed from the atmosphere. The processes involved in the preparation of food from these substances are in this case collectively called assimilation. They can go on only under the action of sunlight, in cells containing chlorophyll; some of the oxygen from the carbonic acid and water is then given off, while the remaining ingredients are combined to form the carbo-hydrates that circulate through the plant to nourish it, support its growth, and supply the material for oxidization as described in the process of respiration. The amount of carbon which an acre of forest trees store up as they grow in one year, in the form of carbo-hydrates of various sorts, is about twenty-six hundred pounds. In the same time the trees consume about one hundred pounds in doing work, leaving a clear gain of more than a long ton of carbon.

Professor Goodale writes me that he is "in the habit of likening the apparently incompatible processes which go on in a plant to the running of a cotton-mill by water-power, while a small part of the manufactured cloth is consumed to drive a small engine used for hoisting and for other purposes; but the mill in which the chlorophyll grains are the looms is kept going by light instead of by water." W. M. D.

The Relation of Climate to Hay-fever.—Dr. Daniel P. Wright, of Tennessee, recently submitted to the State Board of

Health of that State a valuable report on the climatic influence of the Tennessee mountain region on health and disease, especially treating of the subject of asthma and hay-fever. His point of observation was the summit of Roane Mountain, which is 6,394 feet above the Atlantic sea-level. From July 18 to September 11, 1885, the highest temperature recorded was 68° F. in July, 70° F. in August, and 61° F. in September. The writer also states that the daily range of temperature was seldom more than three or four degrees. The mean barometric pressure for the three months mentioned was 24.027. Forty-two observations showed that the relative humidity at the "summit" was over four times as great as that at Nashville, displaying great humidity of the air, noticeable in everything exposed to it. Precipitation was slight, while 1000 feet down the mountain would be heavy rain-fall. With the exception of the balsam-fir, vegetation was stunted. Dr. Wright cites fifteen cases of hay-fever, all of which obtained relief while they remained at the summit of Roane Mountain. Dr. Wright states that some of these cases obtained equal relief during a sojourn in Northern Michigan. The annual periodicity of this disease seems to be as marked in its nature as though more frequent and is greatly aggravated by irritation of the mucous membranes of the nasal passages by many kinds of dust, the pollen of the *ambrosia artemisiæfolia* probably being the most exciting. "The conclusion is irresistible," says Dr. Wright, " that the cause which determines the season at which these paroxysms occur is not any *one* of these irritants, or all of them, but something inherent in the patient himself, in the absence of which no irritant can produce a paroxysm."

Conspicuous among the places in Michigan where persons afflicted with asthma, on hay-fever, may feel confident of obtaining relief are Mackinaw, Petoskey, Charlevoix, and Boyne City. The latter place is a comparatively new resort, and is located at the head of a beautiful lake, sixteen miles long, which opens into Lake Michigan at Charlevoix, and which is navigable to the largest vessels. Fogs are seldom seen at this point, and and its distance from Lake Michigan renders the winds of the

large lake less severe. Many persons obtain complete relief here that obtained only partial relief at some of the other places mentioned. N.

A PARADOXER.—Mr. J. M. Dougherty of Dundaff, Pa., has written for local journals of his state various articles presenting new views of the structure of the world, and writes this journal asking for an opinion on his work, wishing it published even though unfavorable. Mr. Dougherty is a paradoxer in the sense that he publishes views which are new and not in accordance with those generally accepted by scientific men. In this sense the title bears with it nothing obnoxious, all eminent men who have been ahead of the world having been paradoxers for a longer or shorter time. There are, however, and have been, very many paradoxers who have not been, and are not likely to be, eminent men from faults in their logic and methods, and the writer ventures to think that Mr. Dougherty is one of them. He is, however, not one of the worst of the type, for he is a well-read man, and is not, therefore, a paradoxer from ignorance; he is also a man of ability and does not, therefore, belong to the genus of paradoxers from incompetency. His fault is the very common one of serene indifference to facts which do not fit his theories, and he has not learned the necessity of checking his results from step to step by actual experimental inquiry of nature.

The author believes that gravitation is qualitative as well as quantitative, and like most others of his class he runs foul of the person whom he calls "a Mr. Newton." [He also refers to Mr. Ptolemy, and Mr. Pythagoras, but he speaks of the most mystical of great astronomers as "the glorious Kepler."] Atoms are all electro-magnetic, all bodies are magnets, and all forces can be reduced to magnetic force. Space is the fourth state of matter. Each heavenly body has innumerable motions, one due to each other body, and these motions cause it to emit, as it impinges on space, "a wondrous music, an infinite melody."

These statements of some of the author's views will suffice to locate and define him. He is a mystical, unifiying, electro-magnetic paradoxer with an especial animus against the experi-

mental philosophers like Newton. I have only to add, [in order to accent the objection to pure speculation, which is not science and which will not command attention or respect so long as it is pure speculation,] that I would like to hear that wondrous music, that infinite melody. I have watched many heavenly bodies, often during long nights, but I have never heard the melody. What sort of an ear-trumpet should I use? I would like to experiment on the qualitative character of gravitation. If true it could be proven experimentally, and could probably be applied in inventions to valuable practical ends. Will Mr. Dougherty tell us how to bring it out? I would be glad to utilize the electro-magnetic properties of such bodies as wood, cork, charcoal, and petroleum. If an atom is electro-magnetic, what sort of wire is coiled around it, and where is the battery for each one? And when two atoms unite to form one electro-magnet, are there two electric circuits or only one? And if the latter, who arranges the wires? These are only some of the points in his theory on which I would like further information. When these are answered, there are plenty of others.

THE ENGLISH WEATHER SERVICE.—This is on quite a different footing from our own. It is directed by a meteorological council of the Royal Society, consisting of six members, who appoint a secretary as chief executive officer and a marine superintendent and assistant. The service is thus essentially civilian, while ours is military. At the end of the year ending March 31, 1885, the annual report of which lies before me, the council consisted of General Strachey (chairman), Professors Darwin and Stokes, Messrs. Galton and Stone, and Captain Wharton. Mr. R. H. Scott continued as secretary, which office he has held many years. Captain Toynbee was marine superintendent, and Lieut. Baillie, asssistant.

The council pays especial attention to marine meteorology, and has an immense accumulation of observations from every part of the ocean surface except the Arctic and Antartic, Behring Sea, and some parts of the Pacific. These observations are employed in making climatic and barometric charts of the ocean

surface. The extent of this work can be judged by the fact that on March 31, 1885, there were 152 ships pursuing voyages with whom especial arrangements had been made to report to the council. Barometric charts for the Atlantic, Pacific, and Indian Oceans were about ready for the printer at the time of the report.

A second branch of the work of the council is that of weather-telegraphy. Forecasts are issued twice daily, at 11 A. M., and 8:30 P. M. The latter are for the newspapers only. The success of the forecasts is given as 51% for complete success, 7% for complete failure, or 82 for total percentage of success. Special hay-harvest forecasts are issued with the cooperation of the agricultural societies. Their success for 1884 was as follows: complete success 43%, total failure 3%, total percentage of success, 85. Of 461 storm-warnings, 66.4% were justified, and 12.1% failed completely of justification. This is a better record than in any preceding year, beginning with 1874. A system of transatlantic telegrams has been arranged with General Hazen.

Several special researches have been carried on. The study of the harmonic analyzer is continued. An electrical anemometer by Mr. Preece is in the experimental stage, and a few experimental hand anemometers have been tried with reference to their use in detailed study of the wind. The proposal has been considered of studying the velocity and direction of upper air currents by the firing of shells, and some experiments have been made, but the council has not the necessary facilities for extending the work, though they believe it can be usefully done. Experiments on the photographic determination of the distance and direction of clouds continue to be made at Kew, without definite result.

Parliament appropriates from year to year for the expenses of the work. The amount voted is now annually £15,300 ($76,500). The amount actually expended in this year was £14,855, a reduction of over £500 on the year before. The council is paid £1,000 yearly and the secretary £800. Of the appropriation nearly £2,500, or about one-seventh of the whole, was devoted to ocean meteorology, and nearly £1,000 to special

researches. The telegraphic reports and storm-warnings cost £3,136, or about $15,600.

A curious feature of this weather-service is that weather forecasts can not be had for Sundays, and that Good Friday and Christmas day are reckoned as Sundays.

SPECIAL BULLETIN FOR APRIL, 1886.—*Temperature:* During the month of April the temperature has been from one to three degrees above the normal north of San Francisco, including the Sacramento Valley, and extending nearly to the northern boundary of Washington Territory; also on the south-western coast of California, elsewhere, and at San Francisco, it has been from one to two degrees below the average.

Rainfall: An excess of precipitation characterizes the entire Pacific coast, except in the vicinity of Portland, where there has been a slight deficiency. Double the average and over has fallen in Santa Barbara, Ventura, Los Angeles, and the coast portion of San Diego counties, also in Fresno, Merced, and San Benito counties, the Salina Valley and northward, including the coast counties to Mendocino, the Sacramento Valley, south of Tehama county, and extending eastward, including the foot-hills of the Sierra Nevada Mountains.

Season's Rainfall: The total precipitation since July has likewise been above the average, except in Washington Territory and northern Oregon. In California the excess is in some localities double the average. The excess is 50 per cent. above the average in San Diego and northern Los Angeles counties, also from Lake Tulare to Merced county, and thence westerly, including the Salinas Valley; this excess again exists in Delano, Yolo, Sacramento, Yreka, Butler, Colusa, and Mendocino counties.

Frosts: There has been an absence of any destroying frosts during the season.

Rainy Season: The rainy season appears to have ended. In southern California there has been no rain since the 13th; in northern California none since the 17th; during the month prior to these dates rain was almost continuous throughout the State.

Rainfall Table in Pacific Districts for Season and Month to May 1st, 1886.

Stations.	No. of Years.	Average for April.	Total April, 1885.	Average for Season to May 1, 1886.	Total for Season to May 1, 1886.	Stations.	No of Years.	Average for April.	Total April, 1886.	Average for Season to May 1, 1886.	Total for Season to May 1, 1886.
Taloosh Island	2	1.84	7.04	77.14	98.14	Fort Muson	12	1.76	5.08	15.42	28.16
Neah Bay	3	4.85	7.55	100.31	103.95	San Francisco	36	1.95	5.28	23.40	32.67
Port Angeles	2	1.20	2.67	26.24	27.11	Goat Island	7	2.46	3.44	16.50	19.97
Blakeley	8	3.10	2.37	42.16	37.77	Farallone Island	5	1.97	3.52	16 68	25.78
Takoma	1	.....	3.67	.....	36.20	Martinez	8	2.36	3.44	16.16	22.81
Fort Spokane	1	.....	.....	.....	.....	East Brother I'd	7	.94	1.15	7.10	10.98
Spokane Falls	1	.....	1.20	.....	.....	Brentwood	6	1.80	.....	9.03	.....
Pleasant Grove	3	.90	.98	8.74	8.06	Byron	6	2.08	2.23	.....	.....
Fort Townsend	13	1.27	1.58	16.27	18.03	Antioch	7	1.44	2.03	10.78	23.25
Olympia	8	3.76	4.04	54.29	44.50	Stockton	15	1.32	3.25	12.67	16.57
Walla Walla	13	1.61	1.66	13.45	12.30	Lathrop	8	1.81	3.46	11.04	14.53
Fort Canby, W. T.	2	2.05	5.40	46.67	56.29	Tracy	15	.79	1.55	8.63	12.30
Astoria, Oregon	22	4.20	4.99	70.13	61.19	Farmington	9	3.28	4.89	14.55	30.09
Portland	14	3.33	3.16	47.33	39.93	Ione	8	3.30	6.06	18.53	24.30
Eola	0	.....	2.74	.....	36.70	Jackson	8	4.81	8.04	29.54	37.11
Roseburg	8	1.59	4.98	30.40	34.75	Modeste	15	1.02	2.79	8.95	12.79
Bandon	8	4.73	.....	58.34	.....	Turlock	7	1.68	3.01	9.37	15.09
Fort Klamath	1	....	2.77	.....	27.60	Oakland	12	2.27	5.11	23.10	31.91
Ashland	2	1.38	2.63	20.80	24.40	Niles	15	1.54	4.18	16.15	23.75
Sinkville	2	2.64	1.50	.....	.....	Pleasanton	8	2.43	.....	16.96	.....
Lakeview	2	1.64	1.32	17.36	16.42	Livermore	15	1.38	2.36	13.24	16.53
Albany	6	3.72	2.95	43.36	38.74	Point Montura	7	3.22	4.42	22.77	28.02
Crescent City	5	8.57	8.59	83.70	107.98	San Mateo	12	2.04	4.50	18.01	22.62
Yreka	13	.99	.....	.....	.....	Menlo Park	8	2.23	3.34	14.10	18.83
Fort Jones	26	1.79	.....	22.51	.....	Ano Nuevo, C. H	7	3.30	4.15	20.79	23.18
Fort Bidwell	19	1.56	2.20	16.79	21.56	Pigeon Point	7	3.04	5.20	15.43	17.91
Little Hot Springs	1	.....	1.73	.....	24.97	Santa Clara	0	.....	.....	.....	.....
Susanville	1	.....	1.15	.....	17.28	San Jose	12	1.41	4.47	12.01	.....
Orleans	1	.....	8.93	....	55.91	Saratoga	0	.....	.....	.....	.....
Fort Gaston	22	5.00	9.23	53 17	69.41	Los Gatos	1	.....	7.12	.....	42.59
Blue Lake	2	3.98	.....	64.85	.....	Gilroy	12	1.86	4.32	18.84	21.12
Humboldt, L. H	7	3.41	6.53	30.82	41.26	Wright's	1	.....	11.32	.....	51.61
Hydesville	3	3.47	9.15	20.98	54.42	Aptos	1	.....	*7.33	.....	23.72
Cape Mendocino	3	2.39	5.40	17.18	27.35	Santa Cruz	8	3.14	7.60	34.36	32.45
Weaverville	11	3.83	.....	39.82	.....	Livingston	1	.....	.....	.....	.....
Delta	1	.....	10.19	.....	67.08	Merced	13	1.41	.....	10.44	.....
Shasta	...	.....	.....	.....	.....	Athlone	1	....	3.18	.....	16.08
Redding	11	3.28	8.41	34.20	42.51	Central Point	7	1.29	1.91	9.07	15.41
Anderson	1	.....	.....	.....	.....	Firebaugh Ferry	14	.94	2.45	8.15	18.84
Red Bluff	8	2.78	4.10	25.86	34.41	Borden	10	1.17	2.93	8.54	18.27
Tehama	15	1.17	4 00	14.34	22.30	Fresno	8	1.40	2.57	8.41	15.45
Corning	1	.....	3.45	.....	26.34	Selma	0	.....	1.98	.....	.....
Chico	15	1.52	.....	19.55	.....	Kingsburg	7	1.48	2 45	9.74	14.52
Oroville	1	.....	5.48	.....	30.71	Hollister	12	1.14	2.55	11.15	14.29
Orland	7	1.59	2.70	14.17	21 32	Erie	1	.....	5.50	.....	29.10
Willows	7	1.69	2.45	11.37	18.09	Salinas	13	1.21	3.83	13.24	20.56
Princeton	11	1.42	3.53	13.88	21.24	Monterey	6	2.52	3.39	15.40	18.52
Little Stony	1	.....	3.89	.....	26.82	Chualar	8	1.39	2.20	11.27	16.20
Fouls Springs	1	.....	5.01	.....	40.63	Soledad	12	.68	1.93	8.43	14.43
Colusa	14	1.39	3.65	16.02	21.54	Pajaro	12	1.48	5.25	17.37	27.14
Williams	8	1.53	3.01	11.77	18.12	Bishops	2	.10	.38	1.22	.62
College City	2	1.62	.....	.....	.....	Keeler	2	.51	.....	2.82	.....
Westport	1	....	7.77	.....	49.40	Traver	1	.....	.....	.....	.....
Point Arena	7	3.57	7.47	26.26	49.17	Goshen	8	1.17	1.67	7.45	10.62
Laytonville	2	4.98	.....	37.05	.....	Tulure	12	1.01	1.94	6.48	9.25
Uklah	9	3.91	6.43	32.21	44.71	Lemoore	7	1.15	3.35	9.19	17.31
Potter Valley	1	.....	7.55	.....	38.11	San Miguel	1	.....	1.85	.....	23.43
Marysville	15	1.49	5.06	13.62	22.99	San Luis Obispo	16	2.05	.....	20.85	.....
Grass Valley	13	5.16	11.38	47.87	58.32	Delano	10	1.10	.....	5.73	.....
West Butte	6	2.47	4.19	13 83	22.73	Sumner	11	.85	.94	4.66	5.59
Nicolaus	7	2.75	4.93	19.54	26.61	Caliente	10	1.92	2.65	9.96	12.83
Emigrant Gap	15	5.11	.....	47.73	.....	Keene	8	2.12	2.54	12.41	12.66
Colfax	15	5.00	10.86	42.54	49.93	Jehachapi	9	1.48	.....	10.17	.....
Auburn	15	3.35	.....	31.11	.....	Mojave	6	.40	.....	4.92	.....
Rocklin	15	1.83	.....	18.34	.....	Santa Maria	1	.....	3.37	.....	19.15
Georgetown	13	6.65	.....	56.32	.....	Guadalupe	1	.....	3.65	.....	21.56
Placerville	6	7.35	.....	43 40	.....	Point Conception	7	1.69	.....	13.15	.....

RAINFALL TABLE—(*Continued*).

Stations.	No. of Years.	Average for April.	Total April, 1886.	Average for Season to May 1, 1886.	Total for Season to May 1, 1886.	Stations.	No. of Years.	Average for April.	Total April, 1886.	Average for Season to May 1.	Total for Season to May 1, 1886.
Shingle Springs...	18	2.84	.....	32.58	.....	Santa Barbara.....	17	1.51	3.40	16.82	24.24
Folsom	14	2.28	6.78	21.67	34.75	San Buenaventura	10	1.43	1.97	16.17	21.03
Sacramento.....	36	1.87	4.08	19.11	32.20	Nordhoff	4	3.04	6.87	25.24	39.45
Galt	3	2.12	3.58	14.50	19.20	Ravenna	6	.96	3.70	11.10	18.79
Brighton	8	3.51	4.16	15.46	23.32	Marshall	9	1.53	4.27	13.76	24.57
Dunningan.....	9	1.64	3.61	15.16	29.32	San Fernando.....	8	1.76	.....	.....	.....
Woodland	9	2.20	4.10	15.18	32.84	Cahlunga Valley...	3	1.91	3.00	18.76	23.63
Davis.....	14	1.50	4.75	15.15	34.45	Los Angeles.....	8	2.00	3.32	16.86	22.58
Knight's Landing	8	2.39	4.25	15.61	24.08	Spadra	11	1.18	2.85	11.87	16.50
Elmira	0	.....	4.22	.....	.....	Anaheim.....	8	.94	2.51	10.22	14.75
Batavia.....	1	.....	.....	.....	.....	Orange.....	1	.....	2.17	.....	16.92
Suisun.....	14	1.58	4.02	19.12	29.15	Santa Monica.	2	1.06	2.00	15.74	24.68
South Vallejo.. ...	9	3.20	4.82	15.75	25.94	Ontario.....	2	.....	.....	.....	.....
Benecia Bks.....	29	1.58	4.76	15.19	28.02	Cucamonga	1	.....	.....	.....	.....
Winters.....	1	.....	3.90	.....	25.24	Colton.....	9	1.63	.....	9 24	.....
Calistoga.....	13	2.88	7.12	31 69	40.67	San Gorgonia.....	1	.....	1.24	.....	11.04
Napa.....	9	2.81	.....	21.42	.....	San Bernardino....	15	1.67	3.01	15.59	20.25
Santa Rosa.....	0	.....	.....	.....	.....	Riverside	5	1.11	.....	8.77	.....
Sonoma	1	.....	7.39	.....	34.45	Indio.....	8	.07	.....	2.28	.....
Pelaluma	14	1.98	3.74	21.28	27.66	Mammoth Tank....	8	.11	.05	2.16	2.70
Point Reyes.....	7	2.61	2.53	17.84	15.53	Yuma	10	.09	.31	2.49	4.35
San Rafael.....	10	2.08	6.53	36.95	40.72	Foway	7	2.09	2.67	13.40	16.69
Ross Valley.....	1	.....	8.30	.....	45.44	San Diego.....	14	.87	1.95	10.47	16.85
Sancelito..... ..	4	3.34	5.21	24.18	31.80	Fall Brook	1	.....	.....	.....	.....
Point Boulta.....	7	3.73	3.98	24.27	28.96	Otay Messa.....	1	.....	1.62	.....	15.43
Maxinwater Co.....	1	.....	18.39	.....	73.68	Carson City, Nev..	6	1.74	.25	11.35	14.46
Angel Island.....	17	1.27	4.20	20.93	30.18	Tucson, Ariz.....	10	.19	.06	11.67	7.21
Alcatray Island.....	20	1.28	5.43	16.55	31.41	Winnemucca.....	...	.....	1.37	.....	.....
Presidio of S. F.....	31	1.76	4.86	18.93	27.28	Salt Lake City.....	...	.....	.43	.....	.....

NOTES.

The average rainfall for April, and the average for the season to May 1st, 1886, were computed from the records on file in this office for periods of from 2 to 37 years.

SIGNAL SERVICE, U. S. ARMY, DIVISION OF THE PACIFIC,
San Francisco, Cal., May 10, 1886.

FOREIGN STUDIES OF THUNDER-STORMS.—The first aim of the notes on this subject contributed to this and recent numbers of THE JOURNAL was to present a statement of the attitude of the study in Europe, where meteorological services of several countries have paid especial attention to it: reference may here be made to an account of "the method of study of thunder-storms" in Europe, lately published in the proceedings of the American Academy (xxi, 336-347), containing a somewhat detailed statement of the observations required of volunteer observers in the several countries where the investigation has been instituted. A second object of the notes was to collect from scattered

sources a little of the large volume of evidence that might be gathered to show the essentially uniform character of thunder-squalls, as a type of storms, wherever observed and however called. I should be glad to have added extracts from Dr. Hinrich's account of such storms in Iowa, which I believe are the first examples that have been mapped in this country; and a translation of Dr. Köppen's invaluable studies of several years ago would form an instructive conclusion to the series; but it has been found impossible to extend the notes further for the present. W. M. D.

RAIN-GAUGE INVESTIGATIONS.*

Several years ago the difference in the amounts of rain-fall, reported by a number of observers stationed within an area of a few square miles, caused the writer to conclude, that this variation was mainly owing to the difference in the elevation of the gauges above the surface of the ground, or to their faulty design or construction.

For the purpose of substantiating this conclusion the following comparisons were made, in which the only observations used, were those taken during the warmer months of the year, in order to avoid the influence of snow and frost.

The gauges in all cases were very favorably located, and the observations made with much care.

The gauges mentioned in the first three comparisons, were located at two stations situated about five miles apart; those mentioned in the first comparison at one, and those mentioned in the second and third at the other. Storms when the rain-fall was less than one-tenth of an inch in depth were not considered.

Comparison No. 1, was made with two gauges that were purchased from the United States Signal Service. One was located on the ridge-pole of a small building 22 feet above the surface of the ground, and the other was located $\frac{5}{10}$ feet above the surface. The observations used in making this comparison were taken from the middle of June to the latter part of October,

* A paper read at the meeting of the New England Meteorological Society, January 20, 1886.

1879. The total depth of rain-fall measured in the ground gauge was $10\frac{77}{100}$ inches, and the total depth measured in the elevated gauge was $9\frac{44}{100}$ inches, or *ten and one-half per cent. less.*

Comparison No. 2, was made with two of the Draper pattern gauges. One of them was located, like the elevated gauge mentioned in comparison No. 1, on the ridge-pole of a small building $14\frac{87}{100}$ feet above the surface of the ground, and the other was located $\frac{87}{100}$ feet above the surface. The observations used in making this comparison, were taken between April and November, during the five consecutive years from 1879 to 1883. The total depth of rain-fall measured in the ground gauge was $89\frac{59}{100}$ inches, and the total depth measured in the elevated gauge was $81\frac{47}{100}$ inches, or *nine per cent. less.*

Comparison No. 3, was made with two cup gauges. One was located $3\frac{55}{100}$ feet above the surface of the ground on the top of a small post, and the other was located $\frac{55}{100}$ feet above the surface. The observations used in making this comparison were taken from the middle of April to the first of July, 1884. The total depth of rain-fall measured in the ground gauge was $10\frac{55}{100}$ inches, and the total depth measured in the elevated gauge was $10\ \frac{15}{100}$ inches, or *six and seven-tenths per cent. less.*

A summary of these comparisons shows; that a gauge located 3 feet above a ground gauge collected $6\frac{7}{10}$ per cent. less rain-fall, one located 14 feet above a ground gauge collected 9 per cent. less rainfall, and one located $21\frac{55}{100}$ feet above a ground gauge collected $10\frac{1}{2}$ per cent. less rain-fall.

The difference in the amounts collected by these elevated and ground gauges, was undoubtedly owing to the wind; its force, steadiness, and movement either vertical or horizontal, all having had an influence. Personal experience has led the writer to the conclusion (notwithstanding the apparent general belief to the contrary), that, during storms, when the wind is moving with a high velocity, it does not always follow, that gauges considerably elevated above the surface of the ground catch less rain-fall, in proportion to the amount caught by less elevated gauges, than they do during storms when the wind is moving with a much lower velocity; or, in other words, an unsteady wind would

exert more influence towards decreasing the amount of rain-fall caught in elevated gauges, than would a steady wind, the resultant velocity as recorded by ordinary anemometers being the same in both cases.

An illustration of the influence that the construction and design of gauges, may have upon the amount of rain-fall collected in them, can be seen by the following results of two months' observations made during the past summer, with two New England Meteorological Society No. 2 gauges, and two gauges that were purchased from the United States Signal Service. These observations were made at the two stations before mentioned. At each station one New England Meteorological Society gauge, and one United States Signal Service gauge was used, which were located within a few feet of each other, about one foot above the surface of the ground. At one station the total depth of rain-fall collected by the United States Signal Service gauge was $7\frac{87}{100}$ inches, and the total depth collected by the New England Meteorological Society gauge was $6\frac{55}{100}$ inches, or *ten per cent. less.* At the other station the total depth collected by the United States Signal Service gauge was $7\frac{16}{100}$ inches, and the total depth collected by the New England Meteorological Society gauge was $6\frac{11}{100}$ inches, or *fifteen per cent. less.*

The only comments that the writer intends to make concerning these two different kinds of gauges, are, that the New England Meteorological Society gauges were capped with sharp-edged rims, and their measuring tubes were "drawn" very nicely. It was therefore easy to ascertain by measurement if their different parts were of the right proportional dimensions; and the writer's experience with them in this respect was to find them very nearly so.

The United States Signal Service gauges, however, although in good condition, had partly rounded rims about one-eighth of an inch thick, and their measuring tubes were of such form and construction, that their different parts could not be satisfactorily tested by measurement.

In conclusion, the writer would urge upon all those that are

interested in the subject, to exercise a great deal of care in the measurement of rain and snow-fall, not only for its scientific interest, but for the practical benefits that may arise from it in the future. The engineering and scientific value of accurate rain-fall statistics are too well known to require explanation. Examples of their more practical value can be seen by an examination of the records of many important law-suits, that have been brought by the proprietors of water privileges, to recover damages for encroachments that have been going on for years. In these cases rain-fall statistics have frequently played a very important part (in connection with the drainage area of the sources upon which the privileges were located), in estimating the supply of stored or flowing water. Cases can also be cited, in which rain-fall statistics have been of much importance in municipal litigation, more especially in cities where overflows during severe storms, from streets or sewers, that cause more or less damage to abutting property, occasionally occur. In these cases, the amount of rain that fell during the storms that the outflows took place has been of great value, in aiding judgment as to whether the overflows were caused by inefficient drainage on the part of the municipalities, or to the want of proper precautions not having been taken on the part of the abuttors.

Many other illustrations of the value of rain-fall statistics could also be quoted, if time would admit.

EDMUND B. WESTON.

FOREIGN STUDIES OF THUNDER-STORMS.

THUNDER-STORMS IN NORWAY.

The investigation of thunder-storms in Norway was undertaken in 1867 by Professor H. Mohn, Director of the Meteorological Institute at Christiania; the French plan of observations being followed. I have seen only the abstracts of the results reached, presented in the French *Atlas Météorologique* for certain years, and therefore make brief notes in the absence of the original and more recent memoirs. For 1868, there were 1,420 records from 270 well distributed observers. The storms are

found most frequent in summer, and in the interior they are practically absent in winter; they appear on the coast in winter only during severe tempests. The diurnal maximum falls from three to six o'clock in the afternoon; this is better developed in summer than in winter, as in the few storms of the latter season there seems to be a slightly greater frequency by night than by day. Thunder-storms generally appear when the gradients fall to the northeast, north or northwest; and hence in winds from the southeast, south, southwest and west. Most of the storms move from the southwest, or from south or west, and their mean velocity is 38.5 kilometers an hour. They are most violent in winter and near the coast; the numbers expressing the intensity of lightning, thunder and rain being twice as great then as during summer or in the interior. The temperature and the absolute and relative humidity are all above the mean during storms.

The following general considerations are of interest.

The conditions which seem indispensable to the formation of thunder-storms are ascending currents highly charged with water vapor. Such currents result first from high temperatures, but are powerfully aided by the condensation of their vapor; they are found in two kinds of atmospheric conditions.

First: In the summer months and in the interior, a high temperature is found in the afternoon; air flows in from all sides, and rises over the central area; the moister air from the south forms thunder-storms in its ascent. These may be called heat thunder-storms (orages de chaleur). They occur only in summer and in the late hours of the day, and in all their features, except their high temperature, are less pronounced than the storms of the other class.

Second: The most favorable condition for thunder-storms is found when a barometric depression coming from the Atlantic approaches Norway, for in its eastern part, where the winds are from south, and thus are warm and moist, thunder-storms are most numerous; but in the western part they are very rare. The greater share of even the summer storms occur in these cyclonic storms (tourbillons), and in winter they are all of this origin. (Atlas Météorol. de l'observ. imper., 1868. Paris, 1869,

p. D, 15-18). The volumes of the French *Annales* for recent years do not contain reports of the Norwegian studies.

THUNDER-STORMS IN GREAT BRITAIN.

Very little has been done in the systematic study of thunder-storms in Great Britain. Mr. Alex. Buchan has examined "The Diurnal Periods of Thunder-storms in Scotland" (J. Scot. Met. Soc., V, 1880, 324–329), as determined by simple records of occurrence at stations of the Scottish Meteorological Society, and at lighthouses around the coast. A distinct afternoon maximum appears in the yearly totals; three, four and five o'clock, having the highest numbers, while six to nine in the morning have the lowest. But on taking the stations on the northwest alone, and counting over their winter storms, a midnight maximum and noon minimum is found;

Midnight to 3 A. M.	46	Noon to 3 P. M.	21
3—6	33	3—6	31
6—9	26	6—9	33
9—noon.	25	9—midnight.	43

This is confirmed by observations at Stykkisholm, Iceland, where 22 out of the 23 storms known in 14 years occurred in the cold months from October to March, and 20 were heard between sunset and sunrise. Thunder-storms here appear to be winter, nocturnal phenomena. On the east coast of Scotland the storms appear very rarely in winter; but on the west coast where the rainfall is heavy they are relatively common.

R. H. Scott contributes some brief "Notes on the thunder-storms reported to the (British) Meteorological Office during the six years, 1866–71." (Q. J. Met. Soc., i, 1873). Most of the fourteen stations show summer maxima, this being well marked in London; but Valencia, Ireland, has a strong winter maximum. On the east coast many reports are of thunder without lightning; this is attributed to the dissipation of the storms before they reached the North Sea.

THE EURYDICE SQUALL.

The famous "*Eurydice Squall*," in which the British corvette *Eurydice* capsized close on shore near the Isle of Wight, March

24, 1878, is thus described by the Rev. W. Clement Ley, well known as a specialist in the observation of clouds (Symon's Meteorological Magazine, 1878, 33–39).

"As regards the appearance of the storm-cloud, both in its approach and as viewed from the rear, the few observations which I have received are scarcely minute enough to convey a very distinct impression, for the cloud observer is a *rara avis in terris*. The front edge as seen from Worcester striking the Malvern Hills is succinctly described by one spectator as "resembling a white wall." Another, who viewed it from Headly Common in Surrey, calls it an enormous black cloud like a monster balloon. Others speak simply of gathering clouds. Mr. Glyde, one of the best cloud observers in England, informs us that at Torquay "large cumuli, topped with cirri, began to show themselves in N. N. W., and gradually spread over" the sky, the snow and squall commencing thirty minutes after this appearance. This was as nearly as possible what I observed in Leicestershire. White fragmentary cumuli, under a very clear blue sky, had prevailed during the morning. The storm first showed itself in distant N. W. (stretching from W. S. W. to N. N. E.) as a bank of dense white cirro-stratus, with bold cumuli running up into its under surface. I predicted thunder and a squall (the first of which did not occur, while the second exceeded my expectations), about forty minutes before the storm came over, and I believe most weather watchers who chanced to be on the look-out would have made a similar forecast, *at least in this part of the country.* The lines of cirrus gradually spread to the zenith, moving rather slowly from due N. W., their front edge being, as I reckoned it, about twenty miles in advance of the falling snow. As the snow ceased, seventy minutes after it had begun, the nimbus cleared with a straight edge in W. by N. At 4 P. M. this edge could only be seen 20° above the horizon in E. by S., and this edge, composed of high cirri-form cloud, moved at that hour, to my surprise, rapidly from S., S. W. over a N., N. W., under-current.

"Estimating the velocity with which the snow-storm progressed from the time when the snow began to fall at Stony-

hurst, and at Hurst Point lighthouse, we find this velocity to be forty miles per hour. If, however, we reckon from the time of greatest force of what may be called the actual squall, we get the velocity of forty-eight and a half miles. It is perhaps scarcely needful to state that neither of these velocities necessarily represents the velocity of the movement of the air, or the wind occurring in the squall. . . . Thus advanced, as if bent on its tragic mission, this remarkable storm-cloud. About 9 A. M. it left the Northumberland hills covered with deep snow. Seven hours later, it sent its icy blasts down the chines of the Isle of Wight upon the hapless *Eurydice*. . . "

Self-registering thermo and barograph curves are copied from the records at Falmouth and Kew, and present the usual inverse deflections, a rapid fall of temperature occurring with a sudden increase of pressure. In conclusion, Mr. Ley remarks:

"How far the *Eurydice* squall was of an exceptional character it is difficult to decide for the simple reason that we, at present, know very little of the causes or of the morphology of squalls in general. I speak of *squalls* as distinguished from ordinary *storms* on the one hand, and from the very local gusts common in thunder-storms on the other. I have observed that squalls, in this restricted sense, commonly originate in our latitudes somewhat in the rear but almost always on the right hand half of a cyclonic depression. In this respect they resemble our ordinary secondary depressions, and with the latter they appear to be sometimes united, although the majority of our secondaries are not attended by squalls. The few squalls that I have attempted to examine have had much their longest diameter nearly at right angles to the direction of the wind or of the isobars. In these respects the squall of March 24th may perhaps be regarded as typical."

"It seems clear that the disturbance was associated with, and its eastern extremity attached to the secondary depression which passed southeastward down our east coast; and it may be worthy of note that the subsidiary squalls, which occurred at a later hour in the west, stood nearly in the same relation to the other but less important secondary noticed at 6 P. M. over the north of England."

"Whence comes it that in a squall like this the velocity of the wind is much in excess of that corresponding to the barometric gradient at the time of the squall's passage; whereas, before and after the squall, the velocity is low in relation to the gradient? And how is it that the wind-curves around and in the squall are what we should expect if the barometer were lower beneath the squall-cloud than outside of it, whereas they are actually higher."

Two small outline maps accompanying this description show the belt of snow-fall and its relation to the general upper and lower winds at 10 A. M. and 3 P. M. At the latter hour, the storm-front extended along the southern coast from Land's End to Southampton, and thence northeast to the North Sea. It is surprising that in as densely populated a country as England, with so many amateur meteorologists cooperating in the observation of rainfall, nevertheless so little of detailed and discriminate observation on this squall and its clouds could be obtained.

STORMS IN THE PERSIAN GULF.

Two violent squalls were encountered by a submarine cable expedition in the Persian gulf on November 1 and 2, 1869. The second one is thus described by L. Clark (Q. J. Met. Soc., i, 1873, 117–119): The day after the first storm, the cable was spliced up and paying out had already commenced, with a strong south-east wind, when notice was received [by the cable?] that another violent storm from the north-east had passed Bushire and was on its way down the gulf. . . . At 3. P. M. black clouds were seen rising and at 3:52 the storm burst forth with the same suddenness and fury that had characterized the previous one; being daylight many phenomena were observed which were missed the previous night. As the clouds approached they gathered into a peculiar form resembling the cap of a large mushroom, extending entirely across the heavens from one horizon to the other. The lower edge of the mushroom had a rounded and wrinkled margin, but was very sharply defined; the surface was composed of many similar strata, as if melted pitch had been poured out and allowed to solidify in numerous cakes, each rather smaller than the one below. Underneath all there was a dark chaos which soon enveloped the vessels, the wind still blowing aft

[S. E.?]. Suddenly there came a profound calm, and a few hundred yards ahead the squall was seen approaching. The sea, elsewhere covered with full-sized waves, under the influence of the hurricane became one dead level of creamy foam, the top of every wave being swept off into spray as soon it rose. Small whirlwinds swept along the surface carrying up water-spouts towards the clouds, and for a few moments the darkness and breathless calm contrasting with the threatening of the approaching squall, and the lurid light of the sky still gleaming behind, formed a very impressive scene, which was heightened by the incessant roll of distant thunder. In another moment the squall struck the vessels with the same fury as on the previous occasion, and the thermometer fell at once from 81° to 53°; torrents of rain swept the decks, accompanied with continuous flashes of lightning and peals of thunder and a recurrence of all the appearances of the previous night. After about two hours the sky grew bright, and the wind changed into a gale from the south-east followed by a calm. . . . . The barometer remained on both occasions unaffected up to the last moment; but as soon as the storm arrived it rose about two tenths of an inch, and fell again when it passed over, thus showing that the propelling power was pressure from behind, produced by the weight of the falling rain or some other cause, and not vacuum in front as in ordinary storms." The electrical instruments connected with the cable were not affected by the storm.

THUNDER-SQUALLS IN URUGUAY.

David Christison, M. D., resident at San Jorge, Central Uruguay, contributes an excellent account of squalls there known as *Pamperos*,* from which the following description is abridged:

The term *pampero* is often rather indiscriminately applied, and a considerable part of the value of Dr. Christison's paper comes from his careful definition of the word as he employs it. In Dr. Gould's reports—Anales de la oficina meteorologica argentina—*pampero* is applied in another meaning to storms of many hours or even several days' duration with strong winds through-

* On the Pamperos of Central Uruguay, Journ. Scot. Met. Soc., V, 1880, 335–347.

out; and the word is used in this sense by some at least of the sea-captains who enter the Rio de la Plata.

The *pampero*, as Dr. Christison would define it, is a south-west (sometimes west or northwest) wind ushered in by a sudden short squall. In the most perfect examples, there is a preliminary burst of wind, lasting ten to thirty minutes, accompanied by violent electric discharges and heavy rain; they are preceded by a steady rise in temperature and fall in pressure for several days; the temperature falls immediately after them, and the wind, rain and thunder gradually decrease: there is a peculiarly regular formation of the clouds which head the storm. There is, of course, much variation in the intensity of these several features, and indeed some may occasionally be absent; but enough always remain to identify the storm as a mere variation from the well-marked type. They are recorded at all hours of the day, and a little more frequently (at San Jorge) in the morning than afternoon. The coolness produced by the storm is one of its striking characteristics: changes of 33° in six hours and of 44° in fourteen hours have been recorded. Three out of twelve *pamperos* had no thunder; only one was rainless, and of the remaining eleven some had heavy rain, while in others it was very trifling. Before the squall, the wind was invariably gentle and from some easterly point, occasionally shifting to north: the change to south-west was sometimes preceded by a calm; but in most instances, when closely watched, the east or north wind continued to blow, although with diminishing force, until the moment when the squall had supplanted it; but for some time before this, the clouds overhead were either motionless or moving very slowly from the north-west. Perhaps the most striking characteristic of this class of squalls, is the invariably sudden outburst of the wind at its full strength almost from the first, lasting from ten to thirty minutes, and then moderating. A more general statement is thus presented: "After some days of east and north-east wind, with increasing heat, the south-west horizon towards evening gets very black, and as night approaches lightning is visible. The blackness comes gradually nearer, and the lightning from it is almost incessant. Meanwhile the

wind, which has been blowing towards the storm falls, and it is calm or nearly so. In an instant it comes on hard from the south-west, and the air is filled with dust. The gale is almost at its height from the first, and the wind howls so loudly as to overwhelm the noise of the thunder; in a few minutes, rain falls and lays the dust, and quickly getting heavier comes down in torrents. Lightning in a rapid series of flashes (on the 8th of November, 1867, from ten to twenty-two bright flashes per minute were noted in the ten minutes during which the violent outburst of the pampero lasted) illuminates for a few moments the landscape for leagues around, showing cattle on the distant *campos* as plainly as in the day. The next instant the darkness is so intense that the hand held up before the eyes cannot be seen. In about twenty minutes the violence of the storm is over, the thunder is now heard, and the wind, lightning and rain continue with diminished force for an hour or two."

Dr. Christison's description of the clouds along the front of the storm is especially interesting. In the storm of November 28, 1867, about 8 A. M., threatening masses of cloud from the south-west "had advanced near enough to show that at their head marched two dense and perfectly regular battalions of cloud, one behind the other, in close contact yet not intermingling, and completely distinguished by their striking difference in color,—the first being of a uniform leaden grey, while the second was as black as the smoke of a steamer. On arriving overhead, it was seen that the front, although slightly sinuous, was perfectly straight in its general direction, and that the bands were of uniform breadth. As they rushed at great speed under the clouds without meeting with them, preserving their own formation unbroken, their force seemed irresistible, as if they were formed of some solid material rather than vapor. The length of these wonderful clouds could not be conjectured, as they disappeared beneath the horizon at each end, but probably at least fifty miles of them must have been visible. . . . Their breadth was not great, as they only took a few minutes to pass overhead, and appeared to diminish from the effect of perspective to mere lines on the horizon. At the instant when the first band arrived

above me, the wind, which was still blowing, and something more than gently, from the north-east, went round by north to south-west; and at the same time a strong cold blast fell from the leaden cloud, and continued to blow till both bands had passed. From neither of them, however, came lightning or rain; but filling up the sky in the rear of the regular army followed a confused rabble of clouds with a constant rumbling of thunder, and from which evidently rain was falling. It was not, however, till fifteen minutes after the passage of the two regular bands that rain fell where I stood. The storm passing on, obscured the whole sky, wind, rain and thunder continuing for some hours, but only to a moderate degree." Figures of this and another example of a single front wall of cloud are given, and are very acceptable, considering the rarity of illustration in this class of observations. They and the description leave no doubt that the so-called "squall-cloud" is here referred to. The detail of its internal motion is yet to be discovered.

Some account of similar local storms in the Argentine Republic may be found in Dr. Burmeister's Description Physique de la Republique Argentine, vol. ii. (Paris, 1876).

W. M. DAVIS.

Cambridge, Mass., May, 1886.

The following brief extract is of value in confirming the law of distribution of thunder-storms in larger cyclonic areas of low pressure by facts observed, like the above described *pamperos* in the southern hemisphere: it is taken from a manuscript account of the New Zealand system of weather prediction on the basis of baric types, telegraphed from Australia by Dr. James Hector, director of the Colonial Museum, Wellington, N. Z., recently received by the Hydrographic Office at Washington, which I have been allowed to examine by the courtesy of Captain J. R. Bartlett.

When the center of a circular low pressure area stands to the south of New Zealand, moving eastward, there are "S.W. winds and clearing weather on the west coast of the South Island, N.W. rain in the north, and dry N.W. winds on the east coast of the South Island, succeeded by a 'Southerly Buster' with rain

or snow, according to the season. . . . The change from N.W. to S.W. winds is frequently marked by thunder-storms, especially on the west coast of both Islands." W. M. D.

PEKING DUST-STORMS.

Peking, lying in latitude 40° N., has, on the whole, an admirable climate, with a range of temperature decidedly less than that of Chicago and rather less than that of Philadelphia. The autumns are calm, clear, cool, and beautiful; the remainder of the year is agreeable, with two notable exceptions, both of which depend on the fact that the dry season is in the winter, the wet in the early summer.

As to the latter, the spring comes in late and the summer is ushered in rapidly by heavy rains. The drainage of Peking is naturally bad, and rendered worse by art. Large marble sewers were once constructed, but they have now gone to pieces and make the natural drainage still worse. Geat pits are dug at certain places on the streets as catch-basins for sewage. These are not so bad as might be imagined in the dry season, but in the wet season they become abominable, and the population should, on sanitary principles, be swept off every summer. The streets are for the most part unpaved, and the mud becomes almost bottomless. The ancient pavement over parts of streets is now much broken, is never repaired, and the natural roads much worse. The bridges are generally of marble, which is abundant near Peking, but they are also out of repair and thus add to the impassibility of the streets. The rain comes down freely, and Peking in June is a very undesirable place of residence.

The above forms a serious objection, but it is not complained of so much as are the dust-storms. They occur in the dry season, especially in winter and early spring. They come on at irregular intervals, perhaps six or eight times in the season, and last about three days. The wind is westerly, most often northwest, and blows fresh or high. It raises clouds of dust from the streets, which are perfectly dry except as they are wet down with water dipped from the sewer catch-basins, carried on men's

shoulders and spread by throwing from a large basin on the end of a pole. This highly disagreeable liquid is spread on the streets, soaked up by the earth, comminuted by travel, and, raised by the westerly gales, is breathed in by the inhabitants.

But the condition of the streets would not account for the heavy clouds of dust that come down with the westerly gale or dust-storm. It comes on in dense clouds which compel the foreigner to breathe through a cloth mouth-protector and make him look, after an hour's exposure to them, as if he had been drawn through an ash-heap. The fine dust penetrates into the closest room, and after a storm of this sort one can write with his finger on the upper surface of anything, though enclosed and shut up with the greatest care. Food must be dispatched with great speed or it will taste gritty, and a dust-storm is humorously made an excuse for drinking everything from bottles. The dust blinds the traveller, and he must protect his eyes by large goggles.

This abundant dust spreads over a very large territory. It extends eastward from Peking to the sea, and southeastward, (with the wind) it regularly descends as far south as the Hoang-Ho and sometimes reaches Shanghai, beyond the Yang-tse-Kiang, nearly ten degrees of latitude away. It naturally becomes finer with increase of distance, and in its southern limits it is much valued as a fertilizing deposit. Under its influence the Chinese think the soil is gradually, though slowly, being built up, and the surface elevated.

Where so much dust comes from can be scarcely doubted after a glance at the map of eastern Asia. It must come from the great deserts of Mongolia. The character of these storms is also betrayed by a single series of barometric observations, confirming a character suspected from their general characteristics. Such observations have been long carried on in Peking by Dr. Fritsche and I studied the barometer through one dust-storm, that of January 5–7, 1878. This gale came on with slight fall in the thermometer and a rapid change in the barometer, which rose from 786mm. to 797, making several rises and falls of less magnitude in the meantime. The clouds, which the day before the beginning of the storm had been unbroken, rapidly

cleared away. The sun came out but was shorn of his glory; he was so faint as to be capable of inspection by the naked eye, and was set in a close ring, much like Bishop's ring, but close to the sun. The wind was fresh or high and very gusty, showing strongly at the same time the diurnal variations. The air was very dry, and one had a feeling of malaise and nervousness. After the wind went down, the barometer remained high for a day or two and on its descent there was another, but much less marked, dust-storm. The explanation is plain; the dust-storm was the gale accompanying an area of high pressure, which had come from the desert of Gobi and gone eastward. The dryness of the wind and its abundant dust were in part due to this desert which lies west and northwest from Peking, and is not far away. The dust-storm is the analogue of our blizzard with minor differences due to the differences in topography.

The preceding facts are those observed by the writer, and the conclusions those he drew from his own observation.

The dust-storms are observed throughout the south and west of the desert of Gobi and, farther west, are much worse than at Peking. In Khotan, Johnson found them so bad as to sometimes make noon as dark as twilight, necessitating the use of a lamp to read coarse print at midday. Baron von Richthofen in his China, Vol. I, gives the results of his study of their geological effects. The soil of this origin, to the south of the desert, is of very great depth and is characterized by the entire absence of stones. This I had noticed near Peking. Digging in earth for a well or other purpose, one brought to light innumerable fragments of pottery, tiles, and bricks, but no natural stones. The tiles are often found in position at a depth of a score or more of feet under the surface in Peking, showing that the city has been gradually elevated, and the absence of stones shows that the elevating material was brought by the air.

The winds are a source of erosion on the desert, from which they carry off the finer materials almost as fast as the frost and rain make them. They are also a source of air erosion about Peking of a very curious character. They deepen the roads by carrying off their dust, until on old roads near Peking, the

traveller finds himself considerably below the surface; sometimes so much so that when walking, or seated on his cart, his eyes are below the general surface. Baron von Richthofen found the roads farther west thus dug down to a depth of sometimes 50 or 100 feet. M. W. HARRINGTON.

THERMOMETER EXPOSURE.

It may be that the readers of this journal have had a surfeit of discussions on this subject, and would like a change from the abundance of papers on what may seem to be a rather unimportant matter. There has recently appeared, however, so unique a paper on this subject, and one dealing with some of the points in the discussion in so original a manner, that I am tempted to try the patience of the readers of this journal still further. The paper just referred to, entitled "Neue Versuche über die Bestimmung der wahren Lufttemperatur," is written by Prof. Wild, of St. Petersburg, and appears as No. 4 of Vol. X. "Repertorium für Meteorologie." It comprises an investigation covering 32 pages, with a large number of original observations, and leaves little to be desired in the thoroughness with which the different lines of research are carried out. It may be doubted, however, whether the methods employed were sufficiently accurate to enable us to decide as to the entire reliability of the results. It is the object of this paper to present Prof. Wild's method of experiment, and to discuss in a kindly spirit probable sources of error which may have been overlooked, as being of too little consequence to vitiate the results obtained.

This new investigation comprised experiments as follows:

1st. With black and gilded bulb thermometers in the outside shelter of Prof. Wild's normal pattern, the zinc screen having been removed. The gilded bulb was first coppered by the galvanoplastic process, then the copper polished; the latter was then plated with gold, which in turn was highly polished. The two thermometers were joined to a vertical axis which could be put in rapid rotation 10 meters per second.

2d. With the same thermometers, first still, then after rapid

rotation, both in full sunshine. The true air temperature t_a was computed by the use of the formula—

$$t_a = t_m - .15\,(t_s - t_m)$$

in which t_m = the reading of the gilded thermometer and t_s that of the black bulb. This formula was derived entirely from a theoretical discussion of experiments made in laboratories on the absorption and reflection of low degrees of heat by different highly polished surfaces, and not by actual experiment under powerful insolation.

3d. With thermometers exposed in a shelter like Prof. Wild's normal pattern, but with the modification proposed by him for low latitudes. The inside zinc screen of four quarter cylinders was the same as the normal style. The outside wood shelter, about one meter cube, had the south side and roof double-boarded, with a free communicating air space between the boards, and an open bottom and north side, as in the normal pattern. In order to prevent the effect of strong insolation on the east and west sides, in the morning and afternoon, thus heating the louvres, which heat in turn might be communicated to the zinc screen inside, these walls were also double-boarded, the free air space communicating as before with the roof. A revolving fan in the bottom of the zinc screen served to ventilate the thermometers. The height of the thermometers was 3.2 meters above ground.

4th. With a bright bulb sling thermometer at a height of 2 meters above sod, in full sunshine, and in the limited shade of the outside wooden shelter. In this latter case the prism of air from which the sun's rays were excluded and in which the thermometer was used could not have been more than 1.5 meters across.

The following is a brief *resumé* of Prof. Wild's conclusions, based on the above experiments:

1st. The new apparatus, with doubled S., E., and W. walls, gives a temperature (t_a) about 4.5 F. too high.

2d. The Wild normal shelter gives, without ventilation, in the latitude of St. Petersburg (60° N), on calm summer days, with strong insolation, t_a .9° too high. But so great a variation

from the true t_a as was found at Tiflis does not seem possible, and there may be another source of error in the experiments at that place.

3d. A free black bulb thermometer in the outside wooden shelter gives under the same conditions of weather, etc., 2.5° too high t_a.

4th. A free gold plated thermometer gives in the outside wood shelter .4°, too high t_a.

5th. After sunset, on clear days, the thermometer in the normal shelter and the free gilded one in the wood shelter show .4°, and, with the latter exposure, the black bulb 1.8°, too low t_a.

6th. A wholly free black bulb thermometer may give in the sun 7.7°, and a gilded one 1.4°, too high t_a.

7th. The sling thermometer, in the sun, gave .7° too high t_a, and, in the limited shade of the wood shelter, .9° too low t_a! In the evening, after sunset, its depression below t_a was 1.4°.

It is certain that the black and gilded thermometers, with a velocity of 10 meters per second, will give the true t_a under all conditions, by using the formula given above for reducing the readings.

The standard of comparison in all the above experiments was the latter system, but no attempt was made to check the observations of the gilded thermometer, or to determine the accuracy of the formula. Prof. Wild makes a further comment on the first conclusion. In lower latitudes, where insolation is intense, this source of error cannot be obviated by increasing or closing the side walls of the wood shelter, but we must have recourse to ventilation of the zinc screen, or diminish the effect of radiation through a modified form of the outside wood shelter. Prof. Wild also remarks upon the seventh conclusion: "*This, to me, unexpected result, that the sling thermometer, at midday, by full sunshine, in the very limited shade of my wood shelter shows a too low* t_a, *will perhaps lead to a simple method of determining* t_a *: at all events, the same demands a further investigation in behalf of a satisfactory explanation.*"*

* Das mir unerwartete Resultat, dass das Schleuderthermometer auch um Mittag bei vollem Sonnenschein in dem sehr beschränkten Schatten

I will review these conclusions somewhat in detail. Prof. Wild, in adopting the black and gilded (gold-plated) thermometers, has possibly gained a slight advantage over the black and bare bulbs for determining t_a, though this is by no means clear, as will be seen farther on. As I have shown in previous papers, since the maximum and minimum thermometers must necessarily be unventilated, the main inquiry should be as to the exact influence upon the true t_a by any shelter without ventilation; on this account, I have omitted Prof. Wild's investigation and results with ventilation, except so far as these seemed to give a supposed true air temperature with which to compare the various readings. It may be remembered that as we wish to compare the temperature given by a shelter with the true t_a we cannot very well establish different conditions of bulbs under the same kind of shelter, and claim that any of them will give the true t_a; or adopt one of them, having a supposed most favorable condition of bulbs, as a standard with which to compare other readings. This would be simply comparing different conditions of thermometers, ignoring entirely the effect of the shelter, and it would seem as though we are frequently in danger of considering of too much consequence the effects of variations and reflections upon the thermometer, to the neglect of the vitiation of results by the immediate environment. An agreement in readings of two exposures under the above conditions may simply show that both are equally wrong. We must then first establish as nearly an absolute value of t_a as possible, entirely independent of any shelter or screen for the thermometer; we may then compare all other temperatures with that standard As to Prof. Wild's experiments with the S., E., and W., sides of the wood shelter double-boarded, it may be remarked that the results obtained have been already foreshadowed by the present writer. (See this journal, Feb. '85, p. 400; Nov. '85, p. 308, and Jan. '86, p. 412). In this last reference Prof. Wild

meiner Thermometerhütte eine zu niedrige Temperatur zeigt, wird vielleicht zu einer einfachen Methode der Bestimmung der Lufttemperatur führen können; jedenfalls erheischt dasselbe weitere Untersuchungen behufs befriedigender Erklärung.

is quoted as calling this form of shelter a *drawing chimney;* it seems that he described the shelter much better than he knew. The surprising thing about this matter is, that after Prof. Wild finds his three-walls-doubleboarded-wood-shelter so hot he does not immediately conclude, as has been urged repeatedly upon him by the experiments, both in Tiflis and Washington, that doubling even the south wall must produce a harmful effect, differing only in degree from that resulting from inclosing the three walls. Instead of such conclusion, however, he still insists that his normal shelter is correct, and thinks that the enormous errors discovered at Tiflis must be due to outside disturbing influences.

That his normal shelter, when not ventilated, gives at least .9° too high readings in clear, calm and hot summer days, he himself admits; but when he finds the sling thermometer, shaded only by an object casting a shadow not more than two meters across, reading .9° lower than his normal when ventilated, he does not admit that the error is in the latter, where it evidently is, but thinks the matter demands further investigation. His remarks are so surprising that I have italicized them, and have added the original German. I think it will be admitted by nearly all meteorologists that no better method of ascertaining the exact t_a, in the shade can be devised, than by swinging the black and bright or gilded bulbs in the shade of an object one meter cube; hence the above result, with a plain sling thermometer, in the limited shade of the wood shelter, must be regarded as giving very nearly the true t_a in the shade. If anything, the t_a obtained must be slightly in excess of the truth, owing to the effect of heat reflected from the atmosphere and surrounding objects. I do not wish to be understood as implying that the absolute t_a, even in such limited shade, is the same as the absolute t_a in the sun, when there is a calm, but the two temperatures will not probably differ more than .6° at midday, and if there be a slight breeze, which is almost invariably the case, the difference will be even less. If we consider the t_a obtained by the sling in the above shade as equal to the absolute t_a in the sun, (perhaps about .6° higher than the absolute shade t_a) then it is

plain that Prof. Wild's normal shelter, when *ventilated*, will give under the above conditions .9° higher temperature than the absolute t_a in the sun, and 1.5° higher than the limited shade t_a: when unventilated, according to the above second conclusion, the temperature will be 2.4° higher than the absolute limited shade t_a.

Prof. Wild seeks to check the readings of the normal shelter by revolving the black and gilded thermometers in bright sunshine, using the above mentioned formula:

$$t_a = t_m - .15\,(t_s - t_m).$$

The following table presents some of the readings made on two separate days, and shows the extreme difficulty inherent in making satisfactory and comparable observations under such conditions:

OBSERVATIONS OF TEMPERATURE ON CLEAR AND CALM SUMMER DAYS WITH THERMOMETERS HAVING DIFFERENT CONDITIONS OF BULBS AND IMMEDIATE ENVIRONMENT, AT ST. PETERSBURG.

Rotation Thermometers.								Wild's Shelter.	
Time.	Still. Computed.			*10 m. pr sec.			Difference of t_a.		
	Black.	Gilded.	t_a.	Black.	Gilded.	Comp. t_a.	(4) —(7)	Still.	2 m. pr. sec.
JULY 1, 1885.									
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
14.44	93.9	86 7	85.6	89.6	85.6	85.1	0.5	86.4	86.0
14.55	91.6	86.0	85.1	88.9	85.3	84.7	0.4	85.3	84.9
15 12	92.1	86.0	85.1	89.6	85.6	85.1	0.0	85.6	85.3
15.23	94.3	87.4	86 4	90.0	86.7	85.9	0.5	85.8	85.6
Mean...	93.0	86.5	85.5	89.5	85.8	85.2	0 3	85.8	85.4
JULY 3, 1885.									
14.27	76.5	73.9	73 5	74.3	71.8	71.4	2.1	70 9	70.0
14.46	77 9	75.0	74.6	75 4	72.9	72.5	2.1	70.9	70.5
15.53	76.8	74.3	73 9	74.1	72.1	71.8	2.1	70.9	70.5
14.59	76.3	73.9	73.5	74.3	72.3	72.0	1.5	70.9	70.2
15. 7	77.2	75.0	74.7	75.0	75 2	72.9	1.8	70.7	70.7
15.15	77 9	75.4	75.0	74.4	72.1	71.8	3.2	71.6	70.7
15.20	79.9	75.7	75.1	75.4	72.9	72.5	2.6	71.6	70.1
Mean...	77.5	74.7	74.3	74.7	72 5	72.4	2.2	71.1	70.5

* The observations in this space were made after one minute quick rotation of the thermometers.

It will be seen that the results on July 3 are very different from those on July 1. On July 1 the difference between the black and gilded bulbs when still was 6.5°, while on July 3 it was only 2.8° (a small part of this was probably due to the more intense insolation on July 1. Again, while the ventilated gilded thermometer showed a lowering of .7° on July 1, it

showed a lowering of 2.2° on July 3, or three times as much, and the difference in t_a, between the still and rotated readings, as computed on July 1 was .3°, while on July 3 it was seven times as much, or 2.2°. It would seem at first sight as though a decided change was made in the manner of using or exposing the rotation apparatus between July 1 and 3. Possibly there was more reflection and radiation from surrounding objects on the earlier date, which would affect the black much more than the gilded bulb. If the gilded thermometer had not been tested after the gilding, and the gilding had been put on at a temperature below 80°, than a possible explanation of the difference on the two days would be the action of the copper and gold on the bulb, due to their different laws of expansion from glass. These metals have nearly double the cubical expansion of glass, and, if the copper adhered firmly to the glass, a temperature above that used in deposition would tend to enlarge the bulb, and thus give a too low reading of the thermometer, while a temperature below that of deposition would contract the metal film and give too high a reading. It has been fairly shown that the contraction of so fragile a substance as ice may make an ice covered thermometer bulb read .5° too high, so that a variation of this kind plainly might be looked for in the case of a metal film. The results of Prof. Wild's experiments on July 3, showing a difference of 2.8° between the black and gilded bulbs, accord more closely with my own than do those of July 1. While it is impossible to reconcile the descrepancies without knowing more of the attending circumstances, yet it would seem as though we can hardly accept the formula advanced by Prof. Wild without farther experiment. My own results with gilded bulbs, while very interesting, have not been obtained with as perfect instruments as I have desired, but I hope shortly to have more satisfactory thermometers. I am inclined to think, from my results, that the formula advanced by Prof. Wild is not sufficiently general to meet the wants of the case, and that the ultimate formula, with gilded and black bulbs, will be much more complex than the one under discussion. This, as it seems to me, is due to the exceedingly complex nature of the effects upon

a polished metallic covering of the thermometer bulb, by different radiations and velocities of ventilation. If Prof. Wild had compared his difference between black and gilded bulbs (2.8°) on July 3, with t_a 72.1°, with the difference I found between the black and plain glass bulbs (4.3°) in November, while the t_a was 43.1°, I think he would have hesitated a little in his conclusions. If he had suspended a bare glass bulb along side of the gilded bulb, in full sunshine, the result would probably have been somewhat surprising. While I am not positive, yet I am strongly inclined to think, that the gilded bulb would have read higher than the bare glass bulb. I have found a thermometer suspended in the centre of a Regnault's dew-point cup polished to the highest degree, reading in sunshine 5 to 6 degrees higher than a bare bulb thermometer by its side. Prof. Wild still insists on the formula—

$$t_a = t_b - 9.0\,(t_s - t_b)$$

in the case of black and bare bulbs, and he makes the constant with black and gilded bulbs 1–60 of that, while my experiments show conclusively that in the first case the constant should be .6 (or 1–15 of Prof. Wild's), and in the second case it should be somewhat larger than .6. It will be readily seen that there is an enormous difference between these results; a most careful series of experiments can alone demonstrate the truth in this case.

Not the least singular of the results obtained by Prof. Wild, as it seems to me, is that the sling thermometer after sunset gives t_a too low by 1.4°. This is directly contrary to all my observations made hundreds of times. I find at sunset the sling begins to read lower than the Wild shelter, due to the fact that the Wild form lags in its indications, but as soon as increased radiation into space from the north side of the zinc screen begins to take effect, it (the zinc screen) gradually draws nearer and nearer the sling, till at last, three or four hours after sunset, it reads about .1° lower than the sling, in very calm, clear weather. I am inclined to think that one difficulty with Prof. Wild's observations of the sling thermometer is that they are made nearer the sod than those in his normal shelter. The strong radiation into space

from the sod cools that down, and in turn that cools the air above it, and unless the same height is used in all cases, we cannot get good comparable results. If Prof. Wild will swing his sling thermometer on the lee side of his shelter, and at the same height as the thermometers in the latter, he will find the sling the same as, or slightly higher than, the other, three or four hours after sunset. One thing is certain and that is, that no method yet devised will give the true t_a, while the sun is below the horizon, any more accurately than the simple sling thermometer.

The above discussion, and my own experiments, already completely set forth in previous papers, lead to the following conclusions:

1st. We must have some method of determining as nearly as possible the temperature of free air in motion, in full sunshine, without shelter or screen of any kind.

2nd. The sling black and bare bulb thermometers seem to afford the best method of accomplishing this result, though it is possible that a gilded bulb, in addition to the bare bulb, may afford a slightly better value, owing to the fact that dark heat radiation, while affecting black and bare alike, seems to have less effect on the gilded thermometer.

3rd. The formula for use in the case of black and bare bulb sling thermometers is—

$$t_a = t_b - .6\ (t_s - t_b)$$

in which t_a = temperature of the air.

t_b = " " bare bulb thermometer.

t_s = " " black " "

4th. The temperature of the air in sunshine, on still days, is always higher than that of air in even very limited shade.

5th. In testing inaccuracies of shelters, since maximum and minimum temperatures must be dependent on no ventilation, experiments need only be tried without ventilation.

6th. With bright sunshine at midday every direct method of determining air temperature, either in sun or very limited shade, will give too high values.

7th. Toward and after sunset, till before sunrise, no direct

method of determining the air temperature yet devised can equal that by the sling thermometer.

8th. In seeking for the best form of stationary exposure for a thermometer, as perfect a natural ventilation as posible should be provided for after shielding from direct insolation.

9th. An occasional wetting of the thermometer in a driving rain is not objectionable. The equality of readings of dry and wet bulbs under such circumstances is an advantage rather than otherwise.

10th. One of the best shelters, fulfilling the above conditions, is a single louvred wooden shelter about three feet cube, with a double roof having an air space of 6″ between the roofs, and with closed bottom. A slight projection on the inner edge of the louvre extending $\frac{1}{4}$″ or $\frac{3}{8}$″ above it will afford ample protection except against driving rains or mists. The shelter should be placed above sod or on a roof, on posts inclined like a pyramid, six to fourteen feet high, depending on the freeness of the ventilation.

H. ALLEN HAZEN.

February 22, 1886.

NOTE ADDED MARCH 19, 1886.

After a large number of unsuccessful attempts at obtaining a polished metallic covering for a thermometer, one has finally been sent me by Mr. J. A. Brashear, of Pittsburg, Pa. He succeeded in covering four thermometer bulbs with a most beautiful silver coating. Three of these had coats as follows: A, one coat; B, two coats; C, three coats, each of the same thickness. Observation has shown no appreciable difference in the results for the different coats. The following table exhibits preliminary results:

COMPARISON OF DIFFERENT CONDITIONS OF THERMOMETER BULBS.

Out Doors in Sunshine.

No. of Observations.	t_s.	$t_s - t_{sil.}$	C.	$t_s - t_{br.}$	C.
86	62.1	11.0	.30	8.8	.65
In Doors in Sunshine.					
98	87.4	8.7	.29	7.2	.57
Dark Heat Radiation.					
31	78.9	2 3	.22	0 4	6.00

The observations for this table have been made on a very few days, and yet may be regarded as quite close approximations. The results in sunshine are quite satisfactory and accordant, giving the value of the constant in the formula with the silvered bulb about .3, and with the bare glass bulb about .6. Whatever may be the absolute value, it is certain that the *relative* values above are nearly correct, that is, the constant for the bare bulb cannot be much more than twice or thrice that for the silvered bulb. With dark heat radiation the value of the constant was .22 for the silvered bulb and 6.00 for the bare bulb, results which nearly agree with Prof. Wild's theoretical results. It should be noted that the latter observations are difficult to make comparable, as it is well nigh impossible to apply dark heat uniformly to a number of thermometers. Experiments were also tried with a gold covered bulb furnished by the kindness of Dr. Kidder of the Smithsonian Institution. These showed a uniform value of about .40 for the constant. The gold surface, however, was very thin, and it may be that with a thicker surface the constant would be slightly different.

H. A. H.

CORRESPONDENCE.

ANCHOR ICE.

To the Editor:—In answer to a communication from S. T. J. in the May number of your journal and editorial comments thereon, I would like to say that the phenomena of formation of anchor ice has probably received more study in this country than he is aware, as a number of communications have appeared in scientific papers in regard to the subject. On the Boston Water Works anchor ice does not generally make its appearance until about the last week in December and then only when the surfaces are open and free from ice. The whole body of water must be cooled down to the freezing point or even slightly below and then during windy weather which prevents the formation of a sheet of ice on the surface and severe cold, anchor ice is pretty sure to form. I have several times been up all night

fighting it and have had some opportunity to judge of its effects. Wherever there is a current as in the openings and approaches to gate houses the whole body of water seems to be full of the small pieces of anchor ice moving along with the current and showing a decided tendency to unite into large masses which in a short time close gate openings, screens, pipe chambers, etc.

The particles of anchor ice which I have particularly noticed are generally about of the size of a half dollar, and not unlike it in form although somewhat thinner. When a mass of them is struck with a stick they fall apart readily but the only way I have found efficient in breaking up and dispersing the enemy is to turn a jet of steam into the water and during the first part of the winter and until the ponds are frozen over I keep a portable boiler rigged upon wheels which can be quickly moved to any point of attack. Temperature is at the bottom of the mischief, and by keeping a little run of the temperature of the water at different depths and the state of the weather the presence of anchor ice can be predicted.

DESMOND FITZGERALD, C. E.

BROOKLINE, MASS., May 27, 1886.

TORNADO IN CENTRAL INDIANA.

TO THE EDITOR:—The first storm of special note in this vicinity this year occurred in the evening of May 12.

The village of Wilkinson on the I. B. & W. R. R., about 12 miles west of here was greatly damaged. Two persons were killed and several severely injured. The wind, accompanied by a funnel-shaped cloud, struck from the southwest, demolishing three new dwelling houses, and one or two shops. When about half-way through town the cyclone turned straight south, and destroyed Sam White's dwelling, and killed him instantly—a half mile from town. The other person killed was J. W. Smith's little boy four years old.

Several inmates of the destroyed dwellings took refuge in cellars and escaped injury. On the following Sunday the place was visited by thousands of people who contributed several hundred dollars to relieve the sufferers.

About three hours after the calamity at Wilkinson a terrible wreck occurred on the same road, nearly two miles west of New Castle, (13 miles east of Wilkinson.) The east-bound passenger train was moving slowly and cautiously as it approached a great fill of 60 feet. A sharp lookout failed to discover the break below, and the engine and baggage car went down, killing the engineer, fireman, and one passenger. The engineer moved the air-brake in time to save the coaches on the track; though the front end of the foremost car was well over the abyss when it stopped.

The damage here was slight. A small barn was turned quartering on its foundation; and some fences blown down. The rain-fall was 2.04 inches. At 2 P. M. that day my barometer was 29.87; near 7 P. M., 29.59; and 29.83 at 9 P. M.

WILLIAM DAWSON.

SPICELAND, HENRY CO., IND. May 19 1886.

VISIBILITY OF BISHOP'S RING.

TO THE EDITOR:—In Mr. Stone's interesting article on Bishop's ring, he stated that the visibility of the ring did not seem to vary with the visibility of the lower air, since it was sometimes quite bright when near mountains were dim, and was sometimes dim when distant mountains were visible. Observations have been taken for several months on the visibility of the ring and of distant mountains at Blue Hill Observatory and there has seemed to be a close parallelism between the two in New England. The ring has always appeared brightest when the mountains were clearest and disappeared when the mountains disappeared from view. H. HELM CLAYTON.

LITERARY NOTES.

(5) **Elisha Mitchell Scientific Society.** *Journal for the year 1884, 1885.* Raleigh, 1885, Octavo, 100 pages, with engraving of Dr. M. A. Curtis. The activity of this society is a proper source of congratulation. We noticed a previous publication in Vol. 1, p. 281. This annual number contains less of meteorological interest. On pages 50 to 56 is given the abstract of and comments on the meteorological record at Chapel Hill for the

years 1880–84. Pages 9 to 31 are occupied with a sketch of the botanical work of Dr. Curtis and on page 8 is a memorial sketch of another eminent Carolinian, Dr. W. C. Kerr. His death was recent (Aug. 9, 1885) and this annual contains an article by him. H.

(6) **Roumanian Meteorological Institute.** We have before us the numbers 5, 6 and 7 of the *Buletinul* for 1885. In addition to the publication of official acts, statistics, consular reports, and various memoirs on scientific subjects, it contains each month a statement of meteorological observations at Bucharest, taken under the direction of Sr. Hepites. Each number is accompanied by a graphical sketch of the observations. H.

(7) **Benito Viñes, S. J.** *Observaciones magnéticas y meteorológicas del Real Colegio de Belen de la Compañia de Jesus en la Habana.* First trimester, January—March, 1885. Second trimester, April—June, 1885, Folio, Havana. Father Viñes still continues the elegant publications of his observations at Havana, an account of which we have already given (Vol. I, p. 382). The graphic representations are here even more elaborate and perfect than in the earlier numbers. The parts will now be published quarterly instead of annually as heretofore and will therefore appear earlier. The author still continues his study of the relations of magnetic storms in Havana to meteorological storms on the continent north and traces nearly always a close coincidence. H.

(8) **Winslow Upton.** *Distribution of Rainfall in New England, Feb. 10th, 14th, 1886,* from observations reported to the New England Meteorological Society. Reprint from *Science.* Providence, 1886, octavo, 8 pages and map. This is an account of one of the most remarkable rainfalls that ever passed over New England. For a region south of Providence and covering the most of Rhode Island the rainfall was eight inches and upwards. Professor Upton, who writes the account, is director of the New England Meteorological Society. H.

(9) **Dr. Albert Riggenbach.** *Beobachtungen über die Dämmerung, insbesondere über das Purpurlicht und seine Beziehungen zum Bishop'schen Sonnenring.* Basel, 1886. Octavo, 105 pages. This is Dr. Riggenbach's dissertation presented on his admission to the faculty of the University of Basel. Such a dissertation is always required in Germany and Switzerland of the new professor, and the essay must be of high and original character—a requirement which brings out much matter of high order, and could be well introduced into this country. Dr. Riggenbach treats especially of the relations between the remarkable twilight colors and Bishop's ring. He gives a general account of the ring and many observations of his own. Of especial interest is the change in diameter of the ring and he makes it pass into the twilight colors. Both are diffraction phenomena and the colors must be due to very fine cirrus clouds,

though the presence of fine dust particles plays an essential part. More than half the pamphlet is devoted to the author's own observations.

H.

(10) **A. Lancaster.** *Tableaux résumés des observations météorologiques faites à Bruxelles pendant une période de cinquante années (1833-1882), I. Température de l air.* Brussels, 1886. Octavo, 80 pages. This is a reprint from the *Annuaire* of the royal observatory at Brussels, and is edited by the meteorological inspector of the observatory. The tables are complete for the temperature of the air, and include a period of half a century. In some introductory remarks the author indicates the sources of error in the observations and concludes that the mean temperature of the air at the observatory is 9.0° C., within two-tenths of a degree (48.0° F.±0.4°). The observations and averages printed are without the corrections, the precise amounts of some of which could not be exactly determined. H.

(11) **Bailey, F. H.** PRIMARY PHENOMENAL ASTRONOMY FOR TEACHERS AND GENERAL READERS. Northville, Mich., 1886. Duodecimo, 104 pages. This is a simple and unpretentious discussion of the method of teaching phenomenal astronomy with instructions to teachers. Naturally the illustrations are drawn from the author's own instruments, the cosmophere (which I have not seen) and the astral lantern (which I have seen and can praise without reservation). This pamphlet would prove serviceable in the hands of teachers generally, even of those who do not possess the instruments referred to. H.

(12) **Erwin F. Smith.** *The Influence of Sewerage and Water Supply on the Death Rate in Cities.* 8vo., 87 pp. A glance at the literature published today in the interest of sanitary science shows that the subject which is attracting perhaps the most attention is that relating to the disposal of sewerage in cities. The publication reviewed is undeniably a most weighty argument in favor of the construction of good sewers. The enormous fund of information upon the subject which the author has collected and ably presented in his paper displays proof of the most untiring and conscientious labor.

In addition to radical arguments in opposition to the establishment of systems of sewerage there is considerable doubt as to their value expressed by some writers. The present paper is a great step towards a satisfactory removal of such opposition and doubt.

Mr. Smith considers in detail the death rate in cities, and especially analyses the relation of the death rate of typhoid fever and cholera to the existing sewerage system in the same cities.

He assumes as a fundamental principle that typhoid fever and cholera decrease in proportion as a city is well sewered or not well sewered, and selects these diseases for special consideration on account of (1) The

destructive nature of the diseases; (2) their frequent wide prevalence; (3) and their similarity as regards modes of spreading. He says, "ever since typhoid fever was clearly distinguished from typhus fever it has been observed that certain cities and certain localities in cities are more subject to the disease than others. The permanent fouling of the subsoil and consequent infection of the air and water explains these repeated visitations."

In regard to the distributions of deaths from fever in sewered and non-sewered houses in the city of Berlin, Mr. Smith shows that in sewered houses there was one death in every 137.5 houses, and in non-sewered houses one death in 43.0 houses, the danger of death from fever being more than three times as great in non-sewered house as in those properly sewered. A similar result is shown in the statistics relating to Hamburg. Owing to improved systems of sewerage and water supply in London its fever mortality is only one-fifth as great as it was formerly. Dr. Albenois, health officer of the city of Marseilles, says, "cholera has almost exclusively prevailed in the quarters *destitute of sewers.*"

Mr. S. fully discusses the economic value of human life. Its application to the question of sewerage or non-sewerage as a municipal expense is very clear. "The introduction of sewerage systems and water supply systems at any cost is, therefore, the soundest social and financial economy. (1) Because along with greater freedom from sickness, and consequent important saving of time and money, it insures to the individual a greatly increased ability to earn money; and (2) Because the lives which are saved each year increase by so much the total population, and consequently the total bread-winning or money-making and disbursing powers of the community," says the author.

Throughout the paper the bibliographical references are very complete. Appended to the paper are valuable tables and diagrams to aid in the study of the subject. A. W. N.

(13) **Wilhelm Schlemneller.** *Grundzuge einer Thorie der kosmischen Atmospharen.* Prag, 1883. In this pamphlet of fifty pages the author treats of the physical constitution of atmospheres which are subject to a central attraction, using the dynamical theory of gases as a foundation for his investigations.

Special attention should be called to the fact that the author finds the mean normal component of velocity of the molecule of a gas to be only one half as great as that given by Joule, Clausius, Maxwell and others.

As there is apparently no flaw in the demonstration, we reproduce it here.

The author assumes that the molecules move in all directions and have a common velocity v. Now any given point M within the gas is struck by all the molecules which would pass through this point; it may,

therefore, be conceived to lie at the center of a sphere whose radius is v and to be bombarded by these molecules from all sides. The normal component of velocity, with respect to any plane passing through the given point, for any one of these molecules will be $v \cos u$, u being the angle which the direction of motion makes with the normal to the plane. The mean normal component of velocity for all the molecules on one side of the plane will therefore correspond to the mean of all the ordinates to the surface of a hemisphere whose radius is v; but this mean component is evidently equal to one half of the radius of the sphere, or $\frac{1}{2} v$. As any point of the plane can be treated in a similar way, it follows that the mean normal velocity with respect to any plane is equal to one half of the molecular velocity. The values hitherto assigned to certain expressions involved in the formulæ for the pressure of gases become identical with those of the present author if in place of v we substitute $\frac{1}{2} v$.

The following subjects are discussed analytically.

(1) The composition of atmospheres.

(2) The relation existing between pressure and and molecular velocity.

(3) The dependence of the molecular energy on the distance from center of attraction.

(4) The height of atmospheres.

(5) The molecular velocity and pressure expressed in terms of the radius-rector.

(6) Difference in height determined from the difference in pressure.

(7) Density of atmospheres and the relations to other magnitudes; the surface-center of gravity of the atmospheres.

(8) The temperature.

(9) Atmospheres made up of several gases.

(10) Approximate formulæ for atmospheres in which the factors are complicated.

The author concludes with the remark that he does not consider it necessary to give tabular data for the particular case of our own atmosphere, having shown in a pamphlet, which he published in 1880, that the mean values he then obtained corresponded with observed facts, and while he could not claim that this was a positive proof of the correctness of his deductions, they were at least rendered very probable and worthy of being considered. S.

(14) **Wonderland**: *or Alaska and the Inland Passage. Lieut. Fred. Schwatka*, and others. Octavo, 96 pages. This is a very pretty and interesting pamphlet published by the Northern Pacific Railroad. It is well illustrated, and is worth owning.

(15) **J. G. Hagen, S. J.** *Wetter, telegraphie und Sturm warnungen in Nord-Amerika.* Reprint from the Stimmen aus Maria—Laach.

Freiburg, 1886, Octavo, 50 pages. Father Hagen is Professor in the College of the Sacred Heart at Prairie du Chien, and his judgment on American matters is naturally much better than that of most writers in foreign journals. He discusses, here in a thoroughly appreciative manner, the history of the American Signal Service. This is done professedly rather from the standpoint of the history of culture than from that of physics. In this, as in other things, the reverend father traces, as American characteristics, youthful maturity, rapid development, practical use, a vast design, and above all great uniformity. The materials of the essay are drawn from the Reports of the Chief Signal Officer and are consequently familiar to Americans. H.

(16) **Jahrbucher der k. k. Central Austalt fur Meteorologie und Erdmagnetismus.** Officielle Publication. Jahrgang, 1884. New Series Vol. XXI, Entire Series, Vol. XXIX, Vienna 1885, Quarto, 352 pages. This is the official publication of the Austrian weather service of which Dr. J. Hann is director. In the hands of such a veteran meteorologist the work should be well done, and as a matter of fact, this service, as well as this publication, are models of their kind. These year-books are almost entirely filled with the results of observations,—summaries and averages. The field occupied includes magnetic observations to which 48 pages are devoted. The number of stations of all classes was, for 1884, 356, of which 11 are of the first class, 139 of the second, and the remainder of the third.

(17) **Reports, etc** —*Alabama.*—Report of the Alabama Weather Service, published in the printing office of the A. & M. College, by special order of the Board of Trustees. Prof. P. H. Mell, Jr. Director. Octavo, eight pages. January, February and March, 1886, 36 stations.—*Blue Hill Meteorological Observatory*, Blue Hill, Norfolk County, Mass. A. Lawrence Rotch, Proprietor, H. H. Clayton, Observer. Summary for the year ending January 31, 1886; also February and March. Octavo, 4 pages. This observatory is 635 feet above the sea.—*Brussels*, Bulletin météorologique de l'Observatoire royale. Daily, 4 quarto pages with two maps. Subscription price, in the postal union, per year, 30 francs.—*Buffalo*, Office of the Board of Health, statement of mortality accompanied by the daily Meteorological Observations furnished from the Office of the Signal Service. Albert H. Briggs, M. D., Health Physician and Registrar, Sergt. D. Cuthbertson, Observer, weekly 4 pages.—*Canada*, Meteorological Service, Dominion of Canada, Monthly Weather Review, Charles Carpmael, Superintendent, Toronto, 10 pages, Octavo, January, February.—*Carson Observatory*, Carson City, Nevada, Elevation 4,630 feet. Charles W. Friend, Observer, February, March, single sheet.—*Crowborough*, Sussex, England, Summary of a Meteorological Journal kept by C. L. Prince, F. R. A. S., F. R. Met. S., etc., 4 pages.—*Hong Kong*

Observatory. Government Publication, W. Doberck, Government Astronomer. Folio, 12 pages. May to November, 1885, 7 numbers. The observatory also publishes the China Coast Meteorological Register.—*Hydrographic Office*, Navy Department, Washington, J. R. Bartlett, Commander, U. S. N., Hydrographer to the Bureau of Navigation. Pilot Chart of the North Atlantic Ocean. One large chart appearing at the beginning of each month, containing much information useful to navigators and meteorologists. Contains many notes on the use of oil at sea.—*Illinois*, Statistical report of the State Board of Agriculture. Chas. F. Mills, Secretary, Springfield, Dec. 1885, April, 1886. Also monthly weather review for March, 1886, containing summary of meteorological observations made to the Ill. Dept. of Agric. Springfield, 1886, Octavo, 40 pages. Chas. F. Mills, Springfield.—*Indiana*, summary from stations of the Indiana Weather Service of De Pauw University. Prof. W. H. Ragan, Director, Greencastle, January, February, and March, single sheets.—*McGill College Observatory*, Montreal, Canada. Prof. C. H. McLeod, Superintendent. Abstracts of meteorological observations, February, March, single sheets.—*Michigan*, crop report prepared and printed by the Secretary of State. Lansing, Octavo, February 1, (8 pages), March 1, (6 pages), April 1, (4 pages).- *Minnesota* Weather Service. Prof. Wm. W. Payne, Director, Northfield. D. R. McGinnis, Sig. Corps, U. S. N., in charge. Octavo, 4 pages, February, March.—*Missouri* Weather Service. Prof. F. E. Nipher, Director, Washington University, St. Louis, 4 pages with a rainfall map, February, March.—*Nashville* Rainfall Circulars, S. N. Jesunofsky, Sergeant Signal Corps, U. S. N. Weekly, single sheet.—*Nebraska* Weather Service Bulletin. Prof. G. D. Swezey, Director, Boswell Observatory, Crete, Nebraska, Single sheet, February, March.—*New England* Meteorological Society, Bulletin. Prof. Winslow Upton, Providence, R. I., Director. Prof. W. M. Davis, Cambridge, Mass., Secretary. Octavo, 8 pages and a map, January, February, March. Over one hundred stations.—*New York*. Meteorological Observatory of the Department of Public Parks, Central Park, New York, Daniel Drapher, Ph. D., Director. Abstract of the Registers from self-recording instruments for December, 1885. Quarto, 4 pages. Annual report for 1885, 58 pages. Appendix III, included in this, is a report on the cause of pneumonia, with a graphic chart.—*Ohio* Meteorological Bureau. Prof. B. F. Thomas, President, E. H. Marks, Secretary, Columbus. Octavo, January (62 pages), February (55 pages), 40 stations.—*Tennessee*, State Board of Health Bulletin, T. D., Plunkett, M. D., President, J. B. Lindsley, M. D., Secretary, Nashville. Quarto, 16 pages, January, February, March.—*U. S. Signal Service*, Monthly Weather Review, February, prepared under the direction of Gen. Hazen, Chief Signal Officer, by Lieut. H. H. C. Dunwoody, A. S. O., and assistant. Quarto, 28 pages, 5 charts.

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